the focus of a system of lenses, so that the rays may cross in the interior of the prism. This is an unfavourable position for a prismatic analyser, and in the case of a powerful beam of light, such as that from the electric arc, the crossing of the rays within the prism is not unattended with danger to the cementing substance, and to the surfaces in contact with it.

PHILIP R. SLEEMAN

ON VARIOUS SUGGESTIONS AS TO THE SOURCE OF ATMOSPHERIC ELECTRICITY[1]

WE have seen that, taking for granted the electrification of clouds, all the ordinary phenomena of a thunderstorm (except *globe* lightning) admit of easy and direct explanation by the known laws of statical electricity. Thus far we are on comparatively sure ground.

But the case is very different when we attempt to look a little farther into the matter, and to seek the source of atmospheric electricity. One cause of the difficulty is easily seen. It is the scale on which meteorological phenomena usually occur; so enormously greater than that of any possible laboratory arrangement that effects, which may pass wholly unnoticed by the most acute experimenter, may in nature rise to paramount importance. I shall content myself with one simple but striking instance.

Few people think of the immense transformations of energy which accompany an ordinary shower. But a very easy calculation leads us to startling results. To raise a single pound of water, in the form of vapour, from the sea or from moist ground, requires an amount of work equal to that of a horse for about half an hour! This is given out again, in the form of heat, by the vapour when it condenses; and the pound of water, falling as rain, would cover a square foot of ground to the depth of rather less than one-fifth of an inch. Thus a fifth of an inch of rain represents a horse-power for half an hour on every square foot; or, on a square mile, about a million horse-power for fourteen hours! A million horses would barely have standing room on a square mile. Considerations like this show that we can account for the most violent hurricanes by the energy set free by the mere condensation of vapour required for the concomitant rain.

Now the modern kinetic theory of gases shows that the particles of water-vapour are so small that there are somewhere about three hundred millions of millions of millions of them in a single cubic inch of saturated steam at ordinary atmospheric pressure. This corresponds to 1/1600 or so of a cubic inch of water, *i.e.* to about an average raindrop. But if each of the vapour particles had been by any cause electrified to one and the same potential, and all could be made to unite, the potential of the raindrop formed from them would be fifty million million times greater.

Thus it appears that if there be any cause which would give each particle of vapour an electric potential, even if that potential were far smaller than any that can be indicated by our most delicate electrometers, the aggregation of these particles into raindrops would easily explain the charge of the most formidable thundercloud. Many years ago it occurred to me that the mere *contact* of the particles of vapour with those of air, as they interdiffuse according to the kinetic theory of gases, would suffice to produce the excessively small potential requisite. Thus the source of atmospheric electricity would be the same as that of Volta's electrification of dry metals by contact. My experiments were all made on a small scale, with ordinary laboratory apparatus. Their general object was, by various processes, to precipitate vapour from damp air, and to study either (1) the electrification produced in the body on which the vapour was precipitated; or (2) to find on which of two parallel, polished plates, oppositely electrified and artificially cooled, the more rapid deposition of moisture would take place. After many trials, some resultless, others of a more promising character, I saw that experiments on a comparatively large scale would be absolutely necessary in order that a definite answer might be obtained. I communicated my views to the Royal Society of Edinburgh in 1875, in order that some one with the requisite facilities might be induced to take up the inquiry, but I am not aware that this has been done.

I may briefly mention some of the more prominent attempts which have been made to solve this curious and important problem. Some of them are ludicrous enough, but their diversity well illustrates the nature and amount of the difficulty.

[1] By Prof. Tait. Read at the meeting of the Scottish Meteorological Society on March 17, and communicated by the Society.

The oldest notion seems to have been that the source of atmospheric electricity is aërial friction. Unfortunately for this theory, it is *not* usually in windy weather that the greatest development of electricity takes place.

In the earlier years of this century Pouillet claimed to have established by experiment that in all cases of combustion or oxidation, in the growth of plants, and in evaporation of *salt* water, electricity was invariably developed. But more recent experiments have thrown doubt on the first two conclusions, and have shown that the third is true only when the salt water is boiling, and that the electricity then produced is due to friction, not to evaporation. Thus Faraday traced the action of Armstrong's hydro-electric machine to friction of the steam against the orifice by which it escaped.

Saussure and others attributed the production of atmospheric electricity to the condensation of vapour, the reverse of one of Pouillet's hypotheses. This, however, is a much less plausible guess than that of Pouillet; for we could understand a particle of vapour carrying positive electricity with it, and leaving an equal charge of negative electricity in the water from which it escaped. But to account for the separation of the two electricities when two particles of vapour unite is a much less promising task.

Peltier (followed by Lamont) assumed that the earth itself has a permanent charge of negative electricity whose distribution varies from time to time, and from place to place. Air, according to this hypothesis, can neither hold nor conduct electricity, but a cloud can do both; and the cloud is electrified by conduction if it touch the earth, by induction if it do not. But here the difficulty is only thrown back one step. How are we to account for the earth's permanent charge?

Sir W. Thomson starts from the experimental fact that the layer of air near the ground is often found to be strongly electrified, and accounts for atmospheric electricity by the carrying up of this layer by convection currents. But this process also only shifts the difficulty.

A wild theory has in recent times been proposed by Becquerel. Corpuscles of some kind, electrified by the outbursts of glowing hydrogen, travel from the sun to the upper strata of the earth's atmosphere.

Mühry traces the source of electricity to a direct effect of solar radiation falling on the earth's surface.

Lüddens has recently attributed it to the friction of aqueous vapour against dry air. Some still more recent assumptions attribute it to capillary surface-tension of water, to the production of hail, &c.

Blake, Kalischer, &c., have lately endeavoured to show by experiment that it is not due to evaporation, or to condensation of water. Their experiments, however, have all been made on too small a scale to insure certain results. What I have just said about the extraordinary number of vapour particles in a single raindrop, shows that the whole charge in a few cubic feet of moist air may altogether escape detection.

And so the matter will probably stand, until means are found of making these delicate experiments in the only way in which success is likely to be obtained, viz. on a scale far larger than is at the command of any ordinary private purse. It is a question of real importance, not only for pure science but for the people, and ought to be thoroughly sifted by means which only a wealthy nation can provide.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

CAMBRIDGE.—The General Board of Studies propose to appoint, early in Easter Term, a number of Readers and University Lecturers, including the following: a Reader in Comparative Philology, stipend 300*l.* per annum; a Reader in Botany, stipend 100*l.*; University Lecturers in Sanskrit, in Comparative Philology, in Mathematics (one in each group of the Tripos, Part 3), in Applied Mechanics, in Botany, in Animal Morphology, in Advanced Physiology (three), in Geology, in History (five), and in Moral Science; all at 50*l.*, except in Animal Morphology and in Geology, to which 100*l.* is assigned. The University Lecturers will for the most part be chosen from such College Lecturers as open their lectures to the University generally; but the Board is not necessarily restricted to such; nor to persons who may apply. Candidates are to send in their names and testimonials (if any) to the Vice-Chancellor not later than April 25. It is understood that two lectures a week during

term time shall be the minimum during two terms for each lecturer receiving 50*l.* per annum. As far as possible the University Lecturers are to give special personal attention to their pupils, so as to obviate as much as possible the necessity of private tuition in the subject of the lectures; and the students' fees are to be understood as payment for this personal supervision.

The Special Board for Biology and Geology have published a report showing urgent need for a Senior Demonstrator in Elementary Biology and Animal Morphology at 200*l.* a year; the classes have grown enormously, consequent on recent changes in the M.B. examinations. They recommend that the Lecturers, by whose aid Mr. Sedgwick carries on the work of the late Prof. Balfour, shall be appointed University Lecturers, Dr. Hans Gadow in the Advanced Morphology of Vertebrates, and Mr. W. F. R. Weldon in that of Invertebrates. Moreover, they consider an Assistant Demonstrator as well as other occasional demonstrators are required.

Prof. Hughes has written a letter on the subject of the proposed Sedgwick Museum, suggesting that educational utility rather than architectural display should be the principal aim in the building, and pleading strongly against possible curtailment of the site available for the new museum to satisfy demands of other departments. The area now proposed, 240 feet by 50 feet, with room behind for future extension by annexes, &c., is not too large. If sufficient space can be secured for future extension, it is best to place the museum entirely on one floor; but if this is not certain, it would be desirable to have two long rooms one above another, each 20 feet high.

SCIENTIFIC SERIALS

THE *Quarterly Journal of Microscopical Science* for January, 1884, contains:—Notes on Echinoderm morphology, No. vii.: on the apical system of the Ophiurids, by P. Herbert Carpenter, M.A. (plate 1).—On the homologies of the primary larval plates in the test of Brachiate Echinoderms, by W. Percy Sladen (plate 1).—On the origin of metameric segmentation and some other morphological questions, by Adam Sedgwick, M.A. (plates 2 and 3).—On certain abnormalities in the common frog (*Rana temporaria*): (1) the occurrence of an ovotestis; (2) abnormalities of the vertebral column, by A. Gibbs Bourne, B.Sc. (plate 4).—Researches on the intracellular digestion of Invertebrates, by Dr. E. Metschnikoff (translated from *Arbeiten Zool. Instit. Wien*, 1883.—On the ancestral history of the inflammatory process, by Dr. E. Metschnikoff.—The structures connected with the ovarian ovum of Marsupialia and Monotremata, by Edward B. Poulton, M.A. (plate 5).—On the skeletotrophic tissues and coxal glands of Limulus, Scorpio, and Mygale, by Prof. E. Ray Lankester, M.A. (plates 6 to 11).

THE *Journal of Physiology*, vol. iv., No. 6, February, 1884, contains:—On the electrical phenomena of the excitatory process in the heart of the frog and of the tortoise as investigated photographically, by Dr. J. Burdon-Sanderson and F. J. M. Page (plates 13 to 20).—Experiments on the ears of fishes with reference to the function of equilibrium, by Dr. Henry Sewall.—On the influence of certain drugs on the period of diminished excitability, by Dr. S. Ringer and Dr. H. Sainsbury (plate 21).—On the action of digitalis, by Dr. J. Blake.—On the coagulation of the blood, by L. C. Wooldridge, D.Sc.—An investigation regarding the action of rubidium and cæsium salts compared with the action of potassium salts on the ventricle of the frog's heart, by Dr. S. Ringer (plate 22).—Some notes on the fibrin ferment, by S. Lea, M.A., and J. R. Green, B.Sc.

THE *Journal of the Royal Microscopical Society*, February, 1884, contains:—On the constituents of sewage in the mud of the Thames, by Lionel S. Beale, F.R.S. (plates 1 to 4).—On the modes of vision with objectives of wide aperture, by Prof. E. Abbe (figures); and the usual summary of current researches relating to zoology and botany.

Morphologisches Jahrbuch, Bd. ix., Heft 11, contains:—On the comparative anatomy of the excretory sexual organs of insects, by J. A. Palmen.—Contributions to the comparative anatomy of fishes, No. i.; on the cranium of *Amia calva*, L., by Dr. M. Sagemehl (plate 10).—A contribution to a knowledge of the pseudobranchiæ in osseous fishes, by Dr. F. Maurer (plates 11 and 12).—On the morphology of the mammalian teat, by Hermann Klaatsch (plates 13 to 17).

Archives Italiennes de Biologie, tome iv., fasc. 11, December 15, 1883, contains:—New researches on the alterations in organs in diabetes, by Dr. P. Ferraro.—New researches on the normal and pathological anatomy of the human placenta and of that of mammals, being the substance of three letters to Prof. Albert Kölliker, by Dr. G. B. Ercolani.—On the ciliary muscle in reptiles, by Dr. Ferruccio Mercanti.—On the reproduction of epithelium of the anterior crystalline capsule in adult animals under normal and pathological conditions, by Dr. F. Falchi.—On some dangers from fly's excrement, by Dr. B. Grassi.—On the course and termination of the optic nerve in the retina of a crocodile (*Champsa lucius*), by Dr. A. Tafani (with a plate).—On the development of the vertebral column in osseous fishes, by Dr. B. Grassi.—Notice of the death and writings of Dr. P. Burresi, and of the death of Prof. G. B. Ercolani of Bologna.

Rivista Scientifico-Industriale, Florence, January 15.—A description, with illustration, of the seismoscopic clock invented by Brassart Brothers, by E. Brassart.—On the harmonic sounds produced by a fluid discharged through a tube, by Tito Martini.—Variations in the electric resistance of solid and pure metallic wires under varying temperatures; Part i., Historic survey of the works hitherto issued on the influence of temperature on the conductibility and electric resistance of solid and pure metals, by Prof. Angelo Emo.—Account of the semi-incandescent electric lamp invented by Tihon.—A practical application of Newton's rings in motion, by Prof. Augusto Righi.—On the periodical migrations of the *Myoxus glis*, Gml., by S. Mina-Palumbo.—On the nest of the *Geophilus flavus*, by Prof. F. Fanzago.—On the mollusks at present inhabiting the province of Porto-Maurizio, Maritime Alps, by G. R. Sulliotti.

Rendiconti del Reale Istituto Lombardo, February 7.—Obituary notice of Prof. Emilio Cornalia (concluded), by Prof. Leopoldo Maggi.—A short description of the crystals of barium found at Vernasca, by Dr. F. Sansoni.—On the importance of certain symptoms in the diagnosis of sciatica and other affections of the hip, by Dr. G. Fiorani.—Whether women should be permitted to follow the legal profession, by Prof. E. Vidari.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, March 13.—"Notes on the Microscopic Structure of some Rocks from the Andes of Ecuador, collected by Edward Whymper. No. II. Antisana." By Prof. T. G. Bonney, D.Sc., F.R.S.

The specimens examined consisted of one series gathered by Mr. Whymper and another obtained by him from a collector. The latter came from the south-west or west side of the mountain, at elevations probably not exceeding 13,000 feet. Among them are pitchstones and augite-andesites, in which a little hypersthene possibly occurs. Mr. Whymper's own collection contains specimens of the great lava stream on the west side of Antisana, taken at about 12,340 feet above the sea. It is an augite andesite. The remainder represents the rocks forming the upper part of the mountain, collected from a moraine about 16,000 feet above the sea, supplied by occasional crags, which crop out through the snow and are mostly inaccessible. These are a series of augite-andesites, in some of which hypersthene is certainly present.

Linnean Society, March 20.—H. T. Stainton, F.R.S., vice-president, in the chair.—The Rev. Canon Jas. Baker, Mr. W. Brockbank, Mr. Robert Mason, and Mr. Ed. A. Heath were elected Fellows of the Society.—Mr. J. G. Baker showed and made remarks on a supposed hybrid between the Oxlip (*Primula elatior*) and the Cowslip (*P. veris*).—In illustration of his paper, a contribution to the knowledge of the genus *Anaphe*, Walker, Lord Walsingham exhibited a large and remarkable nest containing a packed mass of cocoons, also specimens of the insects and of the larvæ of a species of Congregating Moth of this genus from Natal; and he likewise showed a live example of a dipterous parasite which had emerged from the moth's eggs when hatched. He further stated that the nest and contents had been forwarded to him by Col. Bowker of Durban, and the larvæ were found alive on its receipt in England in August last. Many of the larvæ remained in the nest, but others in companies of twenty to forty occasionally marched out, moving in closely serried rank, much after the manner of the larvæ of the Procession Moth (*Cnethocampa*). From December to February about 250 moths emerged, but, from the difficulty of obtaining their natural food, all died, though a pair bred and the eggs hatched.